Chapter 6
Water Resources

Only sections or other elements of Chapter 6 revised for the Final EIS are included here. These changed sections combined with the unchanged sections of Chapter 6 in the Draft EIS constitute Chapter 6 of the Final EIS. Please see the introduction to the "Changes Made in the Draft EIS in Response to Comments" section for a full explanation.

The following changed elements of Chapter 6 are presented on the indicated pages. All other sections of Chapter 6 remain unchanged from the Draft EIS. Please consult the Draft EIS for those sections.

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6.1.3 Existing Floodways and Floodplains

The Snoqualmie and Tolt River floodways and regulatory 100-year floodplains were reviewed in relation to the proposed treatment plant, conveyance, and discharge alternatives. Floodway and floodplain mapping is based on the FEMA Flood Insurance Study (FIS) and Flood Insurance Rate Maps (FIRMs). The mapping identifies which properties are within the 100-year floodplain and therefore subject to floodplain regulations. Figure 6-1 displays the King County GIS data layer and indicates, on a general scale, the existing floodway and floodplain areas. The King County GIS data is only a graphical representation of the floodplain boundary. The figure illustrates that portions of both the proposed wastewater treatment plant sites are in the 100-year floodplain. In addition to mapping floodprone areas FEMA FIRMs report flood elevations referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). NGVD 29 is a geodetic reference for elevations, completed and adjusted in 1929. These elevations were used to define the mean sea level datum.

The King County GIS data indicates the City-owned site is approximately 70% within the 100-year floodplain. The FEMA FIS reports a base flood elevation (BFE) in the floodplain at the city owned site ranging between 69 and 70 feet. Ground elevations at the city-owned site range between 66 and 70 feet. Comparing the BFE to available ground survey data it is likely that greater than 70% of the site is in the 100-year floodplain.

The King County GIS data indicates the Weckwerth site is approximately 20% within the 100-year floodplain. The FEMA FIS reports a BFE in the floodplain at the Weckwerth Site ranging between 77 and 78 feet. Ground elevations at the Weckwerth Site range between 77 and about 106 feet. Comparing the BFE to available ground survey data it is likely that less than 20% of the site is in the 100-year floodplain.

King County, in collaboration with FEMA and Snohomish County, has recently begun work on the Lower Snoqualmie and Skykomish Flood Study. The study will update flood hazard maps for the lower Snoqualmie River as part of a FEMA Map Modernization Program. The project schedule anticipates that draft work maps will be prepared by mid-2005, preliminary FIRMs in 2006, and official FIRMs in 2007.

6.1.4 Existing Groundwater Resources

The project area is located within the East King County Ground Water Management Area (East King County Ground Water Advisory Committee, 1998a). Most of the valley surrounding the City of Carnation is designated as a critical aquifer recharge area and recognized in King County's Growth Management Act and critical aquifer recharge ordinance (Carollo, 2003b). The City of Carnation operates a single drinking-water well inside the city limits (depth of about 110 feet) with under 1,000 service connections (East King County Ground Water Advisory Committee, 1998b). Springs furnish approximately 90 percent of the city's drinking water (East King County Ground Water Advisory Committee, 1998b).

While site-specific explorations have not been conducted, the groundwater table is reported to be fairly shallow, generally within 5 to 10 feet below the ground surface at the proposed treatment plant sites. This depth is approximately at the river level (HWA GeoSciences, 2003). The King County Soil Survey (U.S. Soil Conservation Service, 1973) indicates that seasonally high water tables in the floodplain in the Carnation area are approximately 1 to 3 feet below ground surface. The higher water table during the winter months is likely a result of increased precipitation (Becker, personal communication, 2004).

In the Stillwater Wildlife Area where the wetland discharge alternative would be located, the near-surface geology is dominated by silt and clay deposited during flood events of the Snoqualmie River (Carollo, 2004b). These deposits are presumed to be underlain by more permeable fluvial deposits of the river. Because of the low-permeability sediments in the upper 10 feet in the Stillwater Wildlife Area, it is expected that there is little surface water/groundwater interaction. Surface water entering the area through streamflow or precipitation does not likely reach groundwater, and it is unlikely that there is significant upward transfer of water in the area (Carollo, 2004b).

In the proposed upland discharge area, a shallow aquifer is generally found at 15 to 20 feet below ground surface (See Chapter 4, Section 4.1.4.3). The discharge locations for the shallow aquifer have not been positively identified. It is believed that much of the water infiltrates downward to a confined aquifer below. In addition to the downward seepage, the shallow aquifer probably also discharges to local streams and wetlands. The Langlois Creek wetlands, in addition to other wetlands in the area, are within the elevation range of the shallow aquifer.

Most if not all of the homes within a 2000-foot radius of the upland discharge area (approximately 50 residences) use private wells for potable water supply. Since it appears there is only one house in the discharge area itself, there is likely only one water supply well in the discharge area (Carollo, 2003c; 2004a). None of the well logs on file with Ecology indicate that water is being withdrawn from the shallow aquifer; all water appears to be drawn from deeper aquifers. Because the area is not sewered, all of these homes are likely served by on-site septic systems. Septic system drainfields release water to the ground, which provides recharge to the groundwater system. In this case, recharge is to the shallow aquifer, although downward seepage does ultimately move this water into the lower confined aquifer as well (Carollo, 2004a).

6.2.2 Treatment Plant Alternatives: Impacts and Mitigation

Floodplain Impacts

Construction and operation of the treatment plant could potentially impact floodplain areas on either the City-owned or Weckwerth site. The Snoqualmie and Tolt River 100-year floodplains indicated on Figure 6-1 were obtained from King County GIS data and provide only a graphical representation. Detailed surveys have not been conducted, and FEMA floodplain studies for the Snoqualmie River are under revision.

Inspection of the GIS data indicates that the City-owned site is partially within the floodplain (approximately 70% or 7 acres). The current FEMA FIS reports base flood elevations (BFEs) ranging between 69 and 70 feet (NGVD 29). Ground elevations of the City-owned site are estimated at between 66 and 70 feet (NGVD 29). Comparing the BFE to the ground elevations suggests the 100-year flood would cover the majority of the site with up to 3 feet of water. No portion of the site is located within the Snoqualmie River floodway. Access to the site would be from Entwistle Street. Existing conceptual design indicates that the treatment plant and access routes to the site could be located on the highest ground of the site to avoid or minimize 100-year floodplain impacts. Until a survey of the site is conducted it cannot be determined if the treatment plant would be in the Snoqualmie River 100-year floodplain. Another factor that could affect whether the treatment plant would be in the Snoqualmie River 100-year floodplain is that the ongoing flood study for the lower Snoqualmie mentioned earlier in this chapter could change the BFEs on the FEMA FIRM and FIS. A change in either the mapped boundary or the BFEs could affect whether the treatment plant is in or out of the Snoqualmie River 100-year floodplain.

As reported earlier in this chapter the Weckwerth site is approximately 20 percent or 1.5 acres within the 100-year floodplain associated with the confluence of the Tolt and Snoqualmie Rivers (Figure 6-1). No portion of the site is located within the Tolt or Snoqualmie River floodway. The current FEMA FIS reports BFEs ranging between 77 and 78 feet (NGVD 29). With the exception of a small depression, the ground elevations of the Weckwerth site are estimated at between 77 and 106 feet (NGVD 29) resulting in less than 1 foot of water covering a small portion of the site during the 100 year flood. Access to the site would be from an existing unpaved road. Existing conceptual design indicates that the treatment plant and access routes to the site could be located on the highest ground of the site to avoid or minimize 100-year floodplain impacts.

If any portion of the treatment plant were built in the floodplain it would result in filling of an area and loss of flood storage capacity. Filling in the floodplain also displaces floodwaters and may cause flooding in other areas, including adjacent properties. Building in the floodplain may also constrict the area where water can flow. This can cause an increase in water velocities that may result in erosion problems.

Stormwater Runoff Impacts

During the dry weather season neither of the alternative treatment plant sites is located in close proximity to a water body that could be affected by runoff from construction. The City-owned site is located approximately 900 feet from the Snoqualmie River, and the Weckwerth site is located approximately 700 feet from the closest portion of the Tolt River mainstem.

A new treatment facility would result in the creation of new impervious surfaces. Runoff from these surfaces could result in additional stormwater runoff if not controlled in accordance with applicable rules and regulations. Stormwater runoff at the Carnation treatment plant would be managed in accordance with Ecology's *Stormwater Management Manual for Western Washington* (Ecology, 2001). See the section in this chapter titled Mitigation Measures Common to All Treatment Facilities for further discussion of stormwater mitigation measures.

Other surface water and groundwater impacts common to both treatment plant sites are discussed in the section titled Impacts and Mitigation Common to All Treatment Facilities.

Mitigation Measures for Treatment Plant Alternatives

Floodplain Mitigation Measures

Both construction and operation mitigation measures could be necessary to avoid potential impacts to the floodplain.

Should construction in the 100-year floodplain occur the following mitigation measures could be applied:

- Removal of excess excavation and other material including construction materials from the 100-year floodplain.
- During the flood season construction materials, temporary structures, and substances hazardous to health should be sited or stored outside the 100-year floodplain.

Any portion of the treatment facility or a discharge facility permanently located within the 100-year floodplain would be designed to meet flood-proofing and/or flood-protection elevation requirements under the City of Carnation development regulations for flood hazard areas, as well as FEMA regulations.

In addition to flood-proofing and/or flood protection the following mitigation measures could be applied:

- Completion of a flood hazard certification to determine if a flood hazard analysis is necessary.
- Perform flood hazard analysis, if determined necessary.
- As directed by the results of the flood hazard analysis create compensatory flood storage for any loss or displacement of flood storage and ensure the base flood elevations are not increased.

Prevention and Containment of Accidental Spills Common to Operation of All Treatment Facilities

If either the wetland or upland discharge alternative were selected, the treatment facility must provide storage to handle emergency and maintenance events to prevent any untreated or partially treated water from leaving the facility (Carollo, 2003a). The volume of emergency storage would equal the maximum daily flow volume of approximately 660,000 gallons. The treatment facility would be designed in accordance with state and federal design requirements and guidelines (Carollo, 2003b). The treatment plant design would include extensive BMPs and source controls to minimize the risk of contamination from spills and leaks, in the rare event that a spill occurs. Spill containment provisions include double-walled storage facilities and emergency cleanup procedures. The site would be sloped to direct any drainage from spill-prone areas (i.e., sludge loading) back to the treatment plant for processing.

Management of Stormwater Runoff Common to Operation of All Treatment Facilities

Stormwater generated in areas of the treatment plant site that could be exposed to wastewater and chemicals would be collected and processed through the treatment plant. Stormwater generated at parking lots and other general areas of the treatment plant site where no wastewater or solids are handled would be routed to biofiltration swales for treatment, and then infiltrated into the ground or directed to natural surface waters.

6.2.3 Discharge Alternatives: Impacts and Mitigation

6.2.3.1 Impacts and Mitigation at River Discharge

Construction Impacts at River Discharge

Construction of the river discharge would temporarily impact water quality with the disturbance of soils and release of sediments into the Snoqualmie River. Short-term increases in turbidity are expected, along with a potential decrease in dissolved oxygen levels in the river in the vicinity of the construction activities.

There are no wetlands mapped by the National Wetland Inventory or King County at the river discharge location. Construction of the discharge would occur within the 100-year floodplain and the floodway of the Snoqualmie River. As described in Chapter 3, the discharge pipe would be installed in the Snoqualmie River at the Carnation Farm Road Bridge. Construction activity along the shoreline could be expected to occur over an estimated one-month period. The discharge pipe would extend roughly 10 to 15 feet into the river and would be anchored on the river bottom.

Installation would require disruption of the bed and banks and possibly partial diversion of the Snoqualmie River around the discharge location. As described in Chapter 3, construction of the discharge would likely be accomplished using open-cut techniques for the on-shore portion. The pipeline would be constructed in an approximately 3-foot-wide trench (refer to Chapter 3 for further discussion). The in-water work would be accomplished in the shortest time possible and could be done using a number of different options including cofferdams, a barge, or a backhoe operated from shore. The appropriate construction methodology would be determined during final design and would comply with applicable permit requirements. In-water excavation related to construction of the discharge pipe is anticipated to be minimal. Some in-water work would be likely associated with pipeline anchoring. In-water work would result in resuspension of sediments in the water column.

Diversion of groundwater could be needed to dewater construction areas for the on-shore portion. Dewatering operations would comply with all appropriate discharge and treatment rules and regulations established by Ecology, and all appropriate construction BMPs would be implemented and maintained. Refer to the section in this chapter titled Impacts and Mitigation Common to All Treatment Facilities for further discussion.

Operation Impacts at River Discharge

The river discharge alternative could discharge an average flow of about 0.4 mgd, or approximately 0.6 cfs, of highly treated water into the Snoqualmie River. This input is small compared to the relative Snoqualmie River flows. Based on 73 years of record, the average Snoqualmie River flow at the proposed river discharge site is 3,738 cfs and the minimum discharge was 239 cfs. The small amount of highly treated water would be entrained into the river current and diluted. Water quality standards and permit requirements for river discharge and the impacts of the discharge on the Snoqualmie River as a water resource are discussed below.

Operational impacts to groundwater quality are not anticipated because discharges to groundwater associated with the river outfall are not expected to occur.

Water Quality Standards for Operation of River Discharge

Municipal effluent discharges from a wastewater facility to a river outfall must receive an NPDES permit and a Water Quality Certification (401 Certification). Ecology bases the NPDES permit upon technology, water quality, and TMDL considerations.

Technology-based limitations are based on federal and state regulations that dictate maximum discharge limits for secondary treatment.

Water quality-based limitations are determined by Ecology based upon ambient river water quality. The regulations also establish criteria for toxic substances that could degrade the receiving water both in terms of aquatic life and for purposes of human health (WAC 173-201A and 173-221).

TMDL-based limitations were calculated by Ecology using a numerical model to establish maximum pollutant load discharges from point and non-point sources based on the TMDL study (Ecology, 1994). As described in the section in this chapter titled Total Maximum Daily Loads, TMDL parameters include BOD, ammonia-N, and fecal coliform bacteria; guidelines have also been established for soluble reactive phosphorus (SRP). Adherence to these discharge limits would maintain water quality in the Snoqualmie River system, particularly during low-flow periods (August to October).

Based on anticipated allowable mixing zones, dilution calculations were performed for the proposed Carnation treatment plant discharge (Carollo Engineers/Cosmopolitan Engineers, 2003). A mixing zone, as discussed early in this chapter, is a volume of receiving water where the mixing results in dilution of discharged water. Minimum dilution factors were then calculated based on the 7Q10 (7-day low flow with a 10-year recurrence interval) critical flow condition, determined to be 443 cfs by the TMDL study (Ecology, 1994). For the proposed river channel discharge area, dilution factors of 8.7 and 116 are allowed for the acute and chronic exposure levels, respectively (Carollo Engineers/Cosmopolitan Engineers, 2003). Dilution factors were calculated based upon a number of criteria including the river and discharge characteristics, and limitations of the acute and chronic water quality standards (WAC 173-201A) (Carollo Engineers/Cosmopolitan Engineers, 2003).

A summary of the resulting potential NPDES permit limitations for discharge to the Snoqualmie River, including dilution considerations, is listed in Table 6-3. These discharge limitations include dilution and would meet all applicable receiving water quality standards. As shown in Table 6-3, summer discharge limitations would occur for BOD_5, ammonia, and soluble reactive phosphorus.

Table 6–3. Potential NPDES Permit Limitations for Discharge to the Snoqualmie River, Carnation Treatment Facility

Parameter	Non-TMDL Season Limits (Nov. – July)		TMDL Season Limits (Aug. – Oct)	
	Average Monthly[1]	Average Weekly[1]	Average Monthly[1]	Average Weekly[1]
BOD_5[2]	30 mg/L, 155 lb/day	45 mg/L, 233 lb/day	30 mg/L, 25 lb/day,	45 mg/L, 233 lb/day,
TMDL Season Limit			*4.5 mg/L* [3][4][5]	*4.5 mg/L* [3][4][5]
TSS [2]	30 mg/L, 155 lb/day	45 mg/L, 233 lb/day	30 mg/L, 155 lb/day	45 mg/L, 233 lb/day
Fecal Coliform Bacteria	200 colonies/ 100 mL	400 colonies/ 100 mL	200 colonies/ 100 mL	400 colonies/ 100 mL
pH	Daily min. $\geq$ 6 Daily max. $\leq$ 9	Same	Same	Same
Ammonia – N	40.1	95.6	40.1,	95.6,
TMDL Season Limit			*8.4 lb/day,'* *1.5 mg/L* [3][4][5]	*8.4 lb/day,'* *1.5 mg/L* [3][4][5]
Total Residual Chlorine	0.063	0.165	0.063	0.165
Arsenic	2.14	3.13	2.14	3.13
Copper	0.025	0.036	0.025	0.036
Cyanide	0.131	0.191	0.131	0.191
Cadmium	0.005	0.007	0.005	0.007
Chromium (hex)	0.90	0.131	0.90	0.131
Chromium (tri)	1.05	1.53	1.05	1.53
Lead	0.050	0.073	0.050	0.073
Mercury	0.001	0.002	0.001	0.002
Nickel	2.61	3.81	2.61	3.81
Silver	0.002	0.003	0.002	0.003
Zinc	0.204	0.297	0.204	0.297
Soluble Reactive Phosphorus				
TMDL Season Limit			*3.0 lb./day,* *0.5 mg/L*[3][4]	*3.0 lb./day,* *0.5 mg/L*[3][4][5]

(1) The average monthly and weekly effluent limitations are based on the arithmetic mean of the samples taken with the exception of fecal coliform bacteria, which is based on the geometric mean.
(2) The average monthly effluent concentration for BOD_5 and TSS shall not exceed 30 mg/L or 15 percent of the respective monthly average influent concentrations, whichever is more stringent.
(3) Daily maximum.
(4) Calculated based on a maximum daily flow of 0.66 mgd.
(5) Water quality concentration limit applies at all flows; mass limit applies at maximum day flow.
Source: Carollo, 2003b.

Water Quality Impacts for Operation of River Discharge

The potential impacts to water quality associated with wastewater discharge are generally related to temperature, bacteria and viruses, nutrients, turbidity, and chemical contamination. A discussion of how each of these could affect water quality in the Snoqualmie River follows. The effect of these water quality impacts on aquatic life, including salmon, is discussed in Chapter 7.

Temperature. Water temperatures can influence water quality. In general, warmer water temperatures in the summer months are of greatest concern. Ambient Snoqualmie River water temperature in the vicinity of Carnation ranges from approximately 49 to 69°F (approximately 9 to 21°C) during the summer (Ecology, 2004a). Because there is currently no centralized wastewater treatment in Carnation, the temperature of highly treated water leaving the proposed treatment facility cannot be forecast with certainty. Using other treatment plants in western Washington as a guideline, it is estimated that highly treated water would leave the plant at approximately 65 to 70°F (approximately 18 to 21°C) during the summer. Highly treated water leaving the Carnation treatment facility would travel for approximately 2.5 hours through the conveyance pipeline prior to being discharged to the Snoqualmie River. During this time it is estimated the water could be cooled by as much as 10°F (Carollo, 2004b). Conservatively assuming a temperature decrease of 5 degrees during conveyance to the discharge site, the warm-weather discharges to the river could range from approximately 60 to 65°F (approximately16 to 18°C).

The average flow of the Snoqualmie River in the vicinity of the river discharge site is 3,738 cfs (USGS, 2003). Very low water levels in rivers are characterized by the statistic known as 7Q10. The 7Q10 refers to the lowest consecutive 7-day streamflow that is likely to occur in a 10-year period. The Snoqualmie River 7Q10 flow in the vicinity of the river discharge is 443 cfs. The treatment plant would discharge an average of approximately 0.6 cfs into the river. The river and treatment plant water temperature estimates provided above, combined with the predicted cooling during travel to the outfall, indicate a minimal difference in temperature between the highly treated water and the receiving environment at the discharge point. The minimal temperature differential would not change the ambient river temperature beyond the mixing zone (less than 300 feet downstream of the outfall). Within the mixing zone, dilution of 0.6 cfs is expected to quickly reduce the temperature of the highly treated water to ambient conditions. The slight change in temperature within the mixing zone could affect water quality by slightly lowering dissolved oxygen levels (warmer water holds less dissolved oxygen than cooler water). However, temperature and dissolved oxygen are expected to be indistinguishable from ambient conditions beyond the mixing zone.

Bacteria and viruses. Bacteria and viruses live in the intestinal tracts of warm-blooded animals and are present in wastewater, surface water, and groundwater. Some pose a threat to human health. Fecal coliform bacteria are commonly tested for in surface and groundwaters as a general indicator of total bacteria and viruses. Ambient water quality data collected by King County in the Snoqualmie River as part of this project (Appendix A, Table A-8) indicate fecal coliform concentrations have ranged from 2 to 68 colonies per 100 milliliters (mL).

Table 6-3 provides anticipated NPDES permit limits for fecal coliform bacteria based upon preliminary calculations (Carollo Engineers/Cosmopolitan Engineers, 2003). Typically, fecal coliform bacteria concentrations are not measurable (less than 2 colonies per 100 mL) following MBR treatment and disinfection (Table 6-2). Therefore, bacteria levels in the receiving water following discharge of the highly treated water are expected to be indistinguishable from ambient conditions in the river.

Nutrients. Nutrients include nitrogen and phosphorus compounds that are essential for life. Nitrogen compounds play an important role in regulating algae growth. Excessive nutrient concentrations can promote algae growth, which in turn can deplete oxygen levels as the algae die, particularly during the summer months when sunlight is the highest and river flows and dilution are the lowest. Low oxygen levels are limiting to salmonids and other cold-water fish, and in cases of extreme depletion, can result in fish mortality.

Table A-8 in Appendix A summarizes the nutrient concentrations measured in the Snoqualmie River between February 2003 and January 2004. Ambient concentrations of ammonia in the Snoqualmie River ranged from less than 0.01 to 0.017 mg/L, and orthophosphorus concentrations ranged from less than 0.002 to 0.0049 mg/L. Table 6-3 indicates the estimated NPDES permit limitation for ammonia and soluble reactive phosphorus (similar to orthophosphorus). Summertime maximum daily limits are estimated to be 1.5 mg/L for ammonia and 0.5 mg/l for soluble reactive phosphorus. Concentrations of ammonia remaining in highly treated water passing through the MBR process are less than 1 mg/L (Table 6-2). This level is below the estimated discharge limitations listed in Table 6-3. Concentrations of Total Phosphorus, soluble reactive phosphorus is a component of Total Phosphorus, during MBR pilot testing were <2 mg/L. It is possible that either chemical or biological treatment will be necessary to reduce phosphorus levels in highly treated water closer the ambient discharge conditions. Nutrients are expected to be indistinguishable from ambient conditions beyond the mixing zone.

Turbidity. Turbidity measured in the Snoqualmie River as part of this project ranged from 0.91 to 9.04 nephelometric turbidity units (NTU) between February 2003 and January 2004 (Appendix A, Table A-8). Elevated turbidity levels can be a concern for aquatic species (refer to Chapter 7 for further discussion). Elevated turbidity levels occur during the winter months associated with stormwater inputs. MBR treatment results in less than 1 NTU in highly treated water (Table 6-2). Therefore, turbidity is not anticipated to increase above ambient conditions as a result of the discharge of highly treated water into the river.

Chemical contaminants. Table A-8 in Appendix A summarizes the concentrations of metals measured in the Snoqualmie River as part of this project. Table 6-3 lists anticipated NPDES permit limitations for metals. Based upon the low level of industry within the Carnation service area and proposed pretreatment of industrial and commercial wastewater, metals concentrations are anticipated to meet NPDES discharge limitations. Metals, including copper, lead, and zinc, may be present in highly treated water. They do not break down and are considered persistent chemicals. In general, metals bind to sediment or particulates suspended in water, but they may also dissolve in water and accumulate in surface sediments or bioaccumulate in the tissues of aquatic life.

Organic chemicals may be either naturally occurring or human-made. In general, organic chemicals biodegrade over time to their component elements, although some persistent organic chemicals may not break down for decades. Organic chemicals include hydrocarbons and solvents present in household cleaners, for example. These compounds are frequently found at low levels in residential wastewater. Because they are not part of the typical residential waste stream, these compounds enter the system in small quantities associated with disposal of paint, cleaning materials, or automotive wastes. There are currently no surface water quality standards for these compounds. Biochemical oxygen demand (5-day) (BOD_5) can be used as an indicator for many of these chemicals. BOD_5 concentrations of less than 2 mg/L are anticipated in the highly treated water (Table 6-2); therefore, discharges of organic chemicals are expected to be minimal.

Water Quantity Impacts for Operation of River Discharge

The proposed river discharge would be located within the 100-year floodplain of the Snoqualmie River. All facets of this discharge system would be designed to withstand 100-year flows without damage to the facilities in accordance with FEMA requirements. Given the relatively small amount of highly treated water being discharged to the Snoqualmie River (an average of 0.6 cfs), no measurable impact on river water levels is anticipated.

Conclusion

As explained above, the combination of expected low concentrations of pollutants in highly treated water from the Carnation Wastewater Treatment Facility and rapid dilution when discharged to the Snoqualmie River are expected to result in no significant adverse impacts to ambient water quality and quantity.

Mitigation Measures for River Discharge Alternative

Compliance with permit conditions dictated by the NPDES and TMDL limitations would ensure that no significant impacts to surface water quality occur. The proposed MBR treatment technology provides a high level of removal for all regulated constituents. In addition to the mitigation measures common to all alternatives described in the section in this chapter titled Mitigation Measures Common to All Treatment Facilities, the following mitigation measures could be used to further minimize potential impacts to water resources:

- Routinely conduct water quality monitoring and reporting in the Snoqualmie River to ensure that the discharge of highly treated water meets or exceeds all water quality standards. This monitoring would occur prior to discharge and in the environment receiving the discharge. If permit standards are not being met, the plant operation would be assessed and if required, treatment would be augmented to remove additional pollutants to meet the standards.
- Design the discharge facility to prevent erosion and to minimize sediment buildup in the outfall. Monitor to assess sediment buildup and document any maintenance needs.
- For all in-water construction, comply with spill containment requirements. In the unlikely event that a construction accident or spill releases contaminants into waterways or the surrounding environment, construction BMPs (such as oil booms and absorbent pillows) would be employed and utilized to contain and minimize the spill.
- For all in-water construction activities, comply with the requirements of WDFW’s Hydraulic Project Approval (HPA), the Corps permit, and King County sensitive areas permit conditions. Conditions of the HPA would likely limit construction to a specific window of time to protect fish and aquatic resources (refer to Chapter 7 for further discussion).
- Restoration after all in-water work will follow WDFW’s Integrated Streambank Protection Guidelines.
- Develop an erosion prevention and sediment control plan and implement it in accordance with Ecology guidelines.

6.2.3.2 Impacts and Mitigation at Wetland Discharge

Under the wetland discharge alternative, highly treated water would be discharged into newly constructed or modified wetlands. There are two options associated with this alternative. First, the Basic Option would involve the construction of wetlands and the addition of highly treated water discharged to those wetlands and to an existing wetland (Figure 3-5). Second, the Expanded Option would include the features of the Basic Option in addition to the removal of an existing fish-passage barrier on the unnamed creek and installation of large woody debris structures at several locations (Figure 3-5). Refer to Chapter 3 for further discussion. Impacts and mitigation measures are similar for these two options as discussed below.

Construction Impacts at Wetland Discharge

Short-term impacts to water quality resulting from soil disturbance and suspension of sediments are likely to occur during construction activities. Test pits would be dug prior to finalizing the design for the wetland complex to help determine the final depth and shape of the wetlands. Excavation volumes have not been finalized but have been estimated based upon desirable wetland depths and habitat features. To construct seasonal wetlands, it is estimated that up to about 4,000 cubic yards could be excavated (Wilson, 2004). Short-term increases in turbidity in nearby surface waters are expected, along with a potential decrease in dissolved oxygen levels in the vicinity of the construction activities.

Under the Basic Option, highly treated water from the treatment facility would be piped to constructed and existing wetlands covering an estimated total of 6 to 8 acres. As shown in Figure 3-5, the pipe would be installed with branches delivering highly treated water to each of the constructed wetlands. Construction activities could result in short-term impacts to water quality as described in Construction Impacts Common to all Treatment Facilities above.

The Expanded Option would involve the installation of large woody debris (LWD) at several locations on the unnamed creek and connected oxbow, and possibly on Harris Creek (Figure 3-5). The LWD clusters would be semi-porous to emulate natural debris. The clusters would retain more water in the affected streams and wetlands than at present and retain it longer into the dry season for the purpose of enhancing wildlife habitat. The construction of the Expanded Option could result in short-term impacts to water quality in the wetland due to the disturbance of soil and suspension of sediments associated with the installation of the clusters. These impacts are anticipated to be minor because construction of the clusters would occur during the dry summer months, would be limited to a construction period of six to eight weeks, and would comply with all applicable permits for in-water work.

Construction-related impacts to groundwater are not anticipated because construction is anticipated to occur above the groundwater table.

Operation Impacts at Wetland Discharge

Under this alternative, an average flow of 0.4 mgd or approximately 0.6 cfs of highly treated water could be discharged into constructed and existing wetlands in the Stillwater Wildlife Area. Highly treated water would enter the wetlands by upwelling through cobbles and gravel overlying the end of the pipe to mimic groundwater flow. Valves on the pipes would allow for controlled distribution of water to the wetlands. Discharge to the wetlands would be designed to mimic dynamic natural processes. Below is a discussion of how the discharge would meet permit and water quality standards followed by a discussion of the potential impacts of discharge. The purpose of the wetlands is not to provide additional “polishing” of the highly treated water being discharged to them; however, removal of some constituents may be an added benefit of the wetland discharge alternative.

Water Quality Standards for Operation of Wetland Discharge

Table 6-2 summarizes the anticipated water quality discharge requirements for the wetland discharge option. As mentioned above, compliance with the NPDES permit conditions would ensure that no significant impacts to surface water quality occur as a result of the discharge. The wetland discharge would also be required to meet Washington State Class A Reclaimed Water Standards. The reclaimed water standards have been developed for the purpose of preventing water quality impacts to the receiving water environment.

Water Quality Impacts for Operation of Wetland Discharge

The potential impacts of discharging highly treated water to receiving surface water quality are generally related to temperature, bacteria and viruses, nutrients, turbidity, and chemical contamination, and are similar to the impacts described above for the river discharge alternative. A discussion of how each of these parameters could affect water quality in both the receiving wetlands and adjacent surface water follows. Ambient water quality monitoring in the wetlands has not been conducted. The effects of these water quality impacts on aquatic life, including salmon, is discussed in Chapter 7.

Temperature. As stated for the river discharge alternative, highly treated water would leave the plant at approximately 65 to 70°F (approximately 18 to 21°C), depending upon the season, and is anticipated to cool as much as 10°F while traveling through the conveyance pipeline to the wetland discharge (Carollo, 2004b). Temperatures in the wetlands are expected to naturally fluctuate throughout the year because of the shallow depth and relatively stable quiescent conditions. Wetland water temperatures vary throughout the day as well as by season, depending upon solar radiation and the wetland characteristics. A shallow, surface flow wetland mimics the ambient air temperature cycle, a rooted aquatic system moderately fluctuates from the ambient air temperature cycle, and a subsurface flow wetland strongly fluctuates from the ambient air temperature cycle (Kadlec and Knight, 1996).

Because the proposed discharge method involves introduction of flow through the subsurface, it is expected that water temperatures may be lower than air temperatures. Still, temperatures could reach 65°F (approximately 18°C) or higher during summer months because the temperature of the highly treated water would be roughly within this range.

A minimal difference in temperature between the highly treated water and the wetland environment could occur. The highly treated water could be slightly cooler or warmer than the receiving wetlands depending upon the time of year. The 0.6 cfs of highly treated water being discharged is expected to disperse into the wetland areas. Any cooling of the wetland waters that may occur during the summer months has the potential to improve water quality by slightly increasing dissolved oxygen levels in the wetland. Any warming of the wetland waters that may occur during winter months could affect water quality by slightly decreasing dissolved oxygen levels in the wetland. These effects are not expected to substantially modify conditions in the wetlands because the surface area of the wetland would disperse the highly treated water. Water temperature in the receiving surface water bodies is expected to be indistinguishable from ambient conditions as a result of the wetland discharge.

Bacteria and viruses. Impacts from bacteria and viruses would be similar to those described for the river discharge alternative. Discharge of highly treated water to the wetlands is not anticipated to increase bacteria levels above ambient conditions. Ambient sources of bacteria in the wetlands include waterfowl, wildlife, and inputs from natural flow sources. Introduction of highly treated water to the wetland system could result in a reduction of bacteria in receiving surface water bodies.

Nutrients. Impacts from nutrients would be similar to those described for the river discharge alternative above. Vegetation in the wetland system would remove nutrients from the water column; however, nutrients are released back into the water column when plants die. Overall, conditions in the wetland would be very similar to a natural wetland system, with fluctuating nutrient levels according to seasonal variations in wetland biota.

Turbidity. Impacts from turbidity would be similar to those described for the river discharge alternative above. Turbidity is not anticipated to increase above what would naturally occur within a wetland system.

Chemical contaminants. Impacts from metals and organics would be similar to those described for the river discharge alternative above. Wetland plants could provide some uptake of residual metals in the discharge water. Wetland plants also slow the movement of water through the wetland system and provide the potential for increased deposition of solids and contaminants adsorbed to the solid particles.

Water Quantity Impacts for Operation of Wetland Discharge

The proposed wetland systems would be located within the 100-year floodplain of the Snoqualmie River. All facets of this discharge system would be designed to withstand 100-year flows without damage to the facilities or reduction in effective floodplain storage volume in accordance with FEMA requirements.

As described in Chapter 3, highly treated water would be discharged to wetlands via upwelling though cobbles and gravel. Highly treated water introduced to these wetland systems would not be the only source of water but would make up a greater percentage during the drier summer months. This would likely have the desired effect of providing inundation of the wetlands year-round.

Highly treated water discharged to the wetlands would either flow overland to adjacent surface waters or infiltrate into groundwater. Adjacent surface waters that could receive waters from the wetlands include the unnamed creek located south and west of the wetlands or the oxbow located north and west of the wetlands. Surface swales or control structures would be constructed to allow water to flow from the wetlands into either the unnamed creek or the oxbow. The oxbow drains to the creek, which drains to the Snoqualmie River. Discharge-related impacts on water levels, erosion, and sedimentation are not expected to be significant because during normal operating conditions, the wetlands would provide flow-moderating effects as well as allowing sediment deposition.

Operational impacts to groundwater are not anticipated due to the limited interaction between surface/subsurface water and groundwater in the proposed wetland discharge area resulting from a silt and clay layer separating the two. This layer extends about ten feet down from the surface. (Carollo, 2004b).

Conclusion

As explained above, the combination of low concentrations of pollutants in highly treated water from the Carnation Wastewater Treatment Facility and the natural tendency of wetlands to attenuate pollutants and water flow are expected to result in no significant adverse affects to ambient ground or surface water quality and quantity.

Mitigation Measures for Wetland Discharge Alternative

See the section in this chapter titled Measures Common to All Treatment Facilities. In addition the following mitigation measures could be used to minimize potential impacts to water resources:

- Comply with all in-water construction activity requirements of WDFW's Hydraulic Project Approval (HPA), Corps 404 permit, and King County sensitive areas permit conditions.
- Comply with the NPDES permit conditions to ensure that no significant impacts to surface water quality occur.
- Comply with WDFW wetland restoration policies and guidelines.
- Conduct water quality monitoring to verify that the discharge of highly treated water meets or exceeds all water quality standards.
- Plant native wetland and riparian species in the wetlands in the areas surrounding the discharge.
- Design the pipeline in the wetlands to prevent erosion and to minimize sediment buildup in the wetland systems. Monitor sediment buildup and document any maintenance needs.

6.2.3.3 Impacts and Mitigation at Upland Discharge

The upland discharge alternative would consist of discharging highly treated water into constructed infiltration basins that would allow the water to percolate into the ground beneath the basins. The water would filter through the soil and eventually mix with groundwater. As a component of groundwater, a portion of the infiltrated water could enter surface waters that flow to the Snoqualmie River. Approximately eight basins would be constructed by excavating and erecting low earthen dikes around half-acre infiltration areas (Figure 3-6). One or two basins would be used at a time. Overflow facilities would be installed in each basin to direct any flows in excess of hydraulic capacity to an adjacent infiltration basin.

Construction Impacts at Upland Discharge

Construction of an upland discharge system could temporarily impact surface water quality with release of sediments into downstream drainages during construction activities. Major construction activities for the upland infiltration basins are estimated to occur over a period of approximately four months. As with any construction project, leaks or spills from construction equipment could occur. Diversion of surface or groundwater from dewatering could also occur, temporarily lowering the groundwater table in the area. These impacts would be short-term and could be minimized by implementing the mitigation measures described in the section in this chapter titled Impacts and Mitigation Common to All Treatment Facilities.

Operation Impacts at Upland Discharge

Access to the upland discharge study area was limited, so site-specific information was not available at the time of this writing. General conditions of the upland discharge study area were obtained from field investigations conducted at the City-owned landfill property located immediately adjacent to the upland study area and from published information (Carollo, 2004a). Three field investigations were conducted on the City-owned landfill property to examine the surface geology and soils; monitor well drilling and testing; and water level monitoring. Soils and water samples were taken during the field investigations and sent to laboratories for analysis. In addition to the field investigations, well log records from the Washington State Department of Ecology were reviewed. Four of the 18 wells reviewed were determined to be sufficiently close to the upland discharge study area that they could be used to further characterize soils and geology in the area. Using this data the feasibility and potential impacts are discussed below.

Impacts to surface water quality associated with operation of the upland discharge are not anticipated. All highly treated water would be infiltrated; however, because the quality of the water would be so high following treatment, there would be minimal impacts to surface waters from inadvertent releases.

Groundwater Quantity Impacts for Operation of Upland Discharge

Groundwater mounding is perhaps the most substantial impact that can occur beneath an infiltration basin (Carollo, 2004a). Groundwater mounding occurs when the infiltrating water backs up instead of continuing to drain downward. The mounded water stays at a shallow depth in the soil. In some cases the mounded groundwater may even show up as wet areas on the surface of the ground, which is then called groundwater flooding. Mounding or “pooling” is a function of basin size and shape, infiltration rate, length of application, aquifer permeability and effective porosity, the preapplication water level in the aquifer, and the permeability of restricting layers impeding vertical flow.

Information from field studies conducted at the City-owned landfill site and analysis of well logs on adjacent properties as part of this project indicates that the shallow aquifer is much less permeable than the geologic materials found at the surface. Mounding calculations indicate that with such a low permeability, the water table would mound and would, under proposed application rates, become totally saturated. This would raise the water table surface and could cause localized flooding (Carollo, 2004a).

For an infiltration basin to drain properly, a minimum of 2 feet is required between the bottom of the basin and the top of the groundwater mound. The 5 feet of material (gravel) at the surface on the City's landfill property that was investigated as part of this study is too thin to properly allow for infiltration. It is likely that gravel would need to consistently be 15 feet thick or more across an application area for infiltration to be feasible. Additional site-specific investigation would be required to determine if the soils would have a sufficient thickness of material (gravel) to support infiltration and this disposal option (Carollo, 2004a).

Groundwater Quality Impacts for Operation of Upland Discharge

The potential impacts to groundwater quality associated with wastewater discharge are generally related to bacteria and viruses, nutrients, and chemical contamination, and are similar to those described earlier for the river discharge alternative. Surface infiltration of wastewater provides additional treatment beyond that achieved in the treatment plant. Improvements in removals of suspended solids, bacteria and viruses, nitrogen/nitrate, phosphorus, some chemicals (including metals), and other constituents have been documented at sites utilizing surface infiltration as a disposal method (Carollo, 2004a). The potential impacts of any remaining pollutants on groundwater quality are discussed below.

Discharges of highly treated water to groundwater would be required to meet the groundwater standards (Table 6-2). Groundwater standards have been developed to protect groundwater resources that are used as drinking water supplies.

Temperature is of less concern for groundwater because of the natural cooling process that occurs through infiltration. Ambient groundwater quality monitoring has not yet been conducted but would be conducted prior to implementing an upland discharge program.

As stated for the river discharge alternative, highly treated water would leave the plant at approximately 60 to 70^{o}F (approximately19 to 21^{o}C), depending upon the season, and is anticipated to cool by as much as 10^{o}F while traveling through the conveyance pipeline to the discharge site (Carollo, 2004b). Ambient groundwater temperatures in the Pacific Northwest are in the vicinity of 50^{o}F (10^{o}C); however, the dilution of discharged flows by ambient groundwater would minimize any effects to groundwater.

Impacts to groundwater from bacteria, viruses, metals, and organic chemicals would be similar to those described for the river discharge alternative. Discharge of highly treated water to groundwater is not anticipated to increase levels of these constituents above ambient conditions. See additional discussion in Chapter 10.

If upland discharge is determined to be feasible, the highly treated water would need to meet the water quality requirements listed in Table 6-2 at the point of discharge. As an added benefit, highly treated water would undergo additional treatment as it percolated through the soil, resulting in further improvement in quality for some parameters. Eventually the infiltrated water would mix with native groundwater. Prior to discharge to the infiltration basins, the highly treated water would meet groundwater quality standards and should be very similar to the quality of the existing groundwater; therefore, the impact to groundwater quality is expected to be minor.

Conclusion

The subsurface conditions and hydrogeology of the upland discharge study area have been established through field investigations and other analysis of adjacent properties; therefore, a level of uncertainty exists. Given this uncertainty, the impacts stated above, including the potential significant impacts associated with groundwater mounding, represent a conservative, worst case scenario.

Mitigation Measures for Upland Discharge Alternative

See the section in this chapter titled Impacts and Mitigation Common to All Treatment Facilities. In addition the following measures could be used to minimize impacts to groundwater resources:

- Comply with groundwater recharge requirements to ensure that no significant impacts to groundwater quality occur. Water quality monitoring and reporting would be conducted in order to verify that the discharge of highly treated water met or exceeded all applicable water quality standards. This monitoring would occur prior to discharge and in the environment receiving the discharge.
- Prepare a groundwater monitoring plan prior to implementation of this discharge alternative. Install and monitor groundwater monitoring wells in accordance with the provisions of the plan.

6.2.5 No Action Alternative

Under the No Action Alternative, there would be no construction of the proposed treatment facility and none of the impacts associated with the facility would occur. Wastewater in Carnation would continue to be disposed of through on-site septic systems. Risk to surface and groundwater quality would continue at present or increased levels as aging systems continued to fail.

A majority of the existing development in Carnation occurred prior to health department jurisdiction over the use of on-site septic systems. The probability that on-site septic systems will fail appears to be relatively high in much of Carnation due to the nature of the criteria under which most of the existing systems were designed and the age of the systems.

The Public Health-Seattle & King County Department of (PHSKC) code considers disposal-only methods such as cesspools, seepage pits, and pit privies as examples of failing on-site septic systems. These types of on-site systems are open-bottom manholes that provide minimal treatment prior to discharge to the ground (other terms used for these types of systems are sumps or drywells). The lack of treatment creates the potential for nitrate, bacteria, and viruses to enter the groundwater. Once in the groundwater, these pollutants can flow to surface waters.

The PHSKC has estimated that approximately 50 percent of the disposal systems within the City of Carnation involve the use of sumps or drywells (Adolfson, 1990). In 1987 the PHSKC declared a public health hazard area based on the number of inadequately treating septic systems and likely contamination of the unprotected aquifer from which drinking water is provided. A recent PHSKC letter stated, “Since this 1987 declaration little has changed in regards to the disposal-only septic systems and their potential to contaminate ground water” (Bishop, 2003). A recent letter from the City of Carnation stated, “Not only will the approximate 50% of old systems continue to fail, many of the newer systems also could fail, due to improper use and/or failing drain fields or lack of reserve areas. Also, most of these newer systems do not fall under the Seattle/King County Health Department's current on-site septic requirements which increase their susceptibility for ground water contamination” (Brandon 2004).

6.5 References

Adolfson Associates, Inc. 1990. Carnation Study Area On-site Sewage Disposal System Alternative Needs Assessment. Draft. January 24, 1990.

Becker, J. 2004. Joe Becker, Robinson, Noble, and Saltbush. Personal communication with King County Department of Natural Resources and Parks.

Bishop, G. 2003. Supervisor, Community Environmental Health, Seattle & King County Public Health Department. Letter to City of Carnation regarding Sewer Development in the City of Carnation. September 9, 2003.

Brandon, B. 2004. City Manager, City of Carnation. Letter to Don Theiler, Division Director, King County Department of Natural Resources and Parks, Wastewater Treatment Division regarding Carnation Wastewater Treatment Facility Draft Environmental Impact Statement. August 9, 2004.

Carollo Engineers. 2003a. Carnation Wastewater Treatment Facility, Technical Memorandum No. 6, Treatment Process Configuration – Draft. November 2003. Seattle, WA: Prepared for the King County Department of Natural Resources and Parks.

Carollo Engineers. 2003b. Carnation Wastewater Treatment Facility, Technical Memorandum No. 11, Evaluation of Discharge Alternatives – Draft. November 2003. Seattle, WA: Prepared for the King County Department of Natural Resources and Parks.

Carollo Engineers. 2003c. Carnation Wastewater Treatment Facility, Technical Memorandum No.1, Siting Analysis – Draft. July 2003. Seattle, WA. Prepared for the King County Department of Natural Resources and Parks.

Carollo Engineers. 2004a. Carnation Wastewater Treatment Facility, Technical Memorandum No. 5A, Upland Disposal Alternatives – Draft. March 2004. Seattle, WA: Prepared for the King County Department of Natural Resources and Parks.

Carollo Engineers. 2004b. Carnation Wastewater Treatment Facility, Technical Memorandum No. 5B, Hydrologic Aspects of the Wetland Disposal Alternative – Draft. March 2004. Seattle, WA: Prepared for the King County Department of Natural Resources and Parks.

Carollo Engineers and Cosmopolitan Engineers. 2003. Carnation Wastewater Treatment Facility, Technical Memorandum No. 12, Outfall Evaluation – Draft. Seattle, WA: Prepared for the King County Department of Natural Resources and Parks.

East King County Ground Water Advisory Committee. 1998a. East King County Ground Water Management Plan, Management Strategies. Final. December 1998.

East King County Ground Water Advisory Committee. 1998b. East King County Ground Water Management Plan Supplement 1 – Area Characterization. Final. December 1998.

Ecology (Washington State Department of Ecology). 1994. Snoqualmie River Total Maximum Daily Load Study. Ecology Report #94-71 by Joe Joy. May 1994. Olympia, WA: Washington State Department of Ecology.

Ecology (Washington State Department of Ecology). 2001. Stormwater Management Manual for Western Washington, Vols. I-V. Ecology Publications 99-11 through 99-15. Olympia, WA.

Ecology (Washington State Department of Ecology). 2003 The 303(d) list of impaired and threatened waterbodies, last updated July 2003. Retrieved from http://www.ecy.wa.gov/programs/wq/303d/index.html

Ecology (Washington State Department of Ecology). 2004a. River and Stream Water Quality Monitoring data. Retrieved from http://www.ecy.wa.gov/apps/watersheds/riv/station.asp?theyear=&tab=notes&scrolly=0&sta=07D100

Ecology (Washington State Department of Ecology). 2004b. Snoqualmie River Total Maximum Daily Load Effectiveness Evaluation, Quality Assurance Project Plan. January 2004.

Haring, D. 2002. Salmonid Habitat Limiting Factors Analysis: Snohomish River Watershed, Water Resource Inventory Area 7, Final Report. Olympia, WA: Washington Conservation Commission.

HWA GeoSciences, Inc. 2003. Carnation Wastewater Treatment Facility, Technical Memorandum No. 3, Geotechnical Reconnaissance – Draft. September 2003. Seattle, WA: Prepared for the King County Department of Natural Resources and Parks.

Joy, J. 2003. Environmental Assessment Program, Washington State Department of Ecology. Personal communication in e-mail to Bob Storer, Adolfson Associates, Inc. November 4, 2003.

Kadlec, R.H., and R.L. Knight. 1996. Treatment Wetlands.

King County. 2002. Snoqualmie Watershed Aquatic Habitat Conditions Report: Summary of 1999 – 2001 Data. November 2002.

King County. 2003. Unpublished water quality data for Snoqualmie and Tolt Rivers and Harris Creek.

Pacific Groundwater Group, Inc., and associated firms. 1995. Snohomish River Watershed Initial Assessment. Prepared in cooperation with Washington Department of Ecology. Draft. May 1995.

Stahlschmidt-Allner, P., Allner, B., Rombke, J., and Knacker, T. 1997. Endocrine disruptors in the aquatic environment. Environmental Science Policy Research 4 (3), 155-162.

Ternes, T.A., Stumpf, M., Mueller, J. Haberer, K. Wilken, R-D., and Servos, M. 1999. Behavior and occurrence of estrogens in Municipal sewage treatment plants. I. Investigations in Germany, Canada and Brazil. Science of the Total Environment 255, 81-90.

U.S. Department of Agriculture, Soil Conservation Service. 1973. Soil Survey of King County Area, Washington. November 1973.

USGS (U.S. Geological Survey). 2003. Streamflow gaging information obtained from http://wa.water.usgs.gov/realtime/htmls/snoqualmie.html

Williams, R.W., R.M. Laramie, and J.J. James. 1975. A Catalog of Washington Streams and Salmon Utilization: Volume 1, Puget Sound Region. Olympia, WA: Washington State Department of Fisheries.

Wilson, D. 2004. Memorandum by Dean Wilson, King County Water and Land Resources Division, Regarding Conceptual Design for the Creation and Enhancement of Wetlands Habitat in the Stillwater Wildlife Area Wetlands Using Reclaimed Water from the Proposed Carnation Wastewater Treatment Plant.

Wintgens, T., M. Gallenkemper, and T. Melin. 2002 Endocrine disrupter removal from wastewater using membrane bioreactor and nanofiltration technology. Desalinization 146, 387-391.

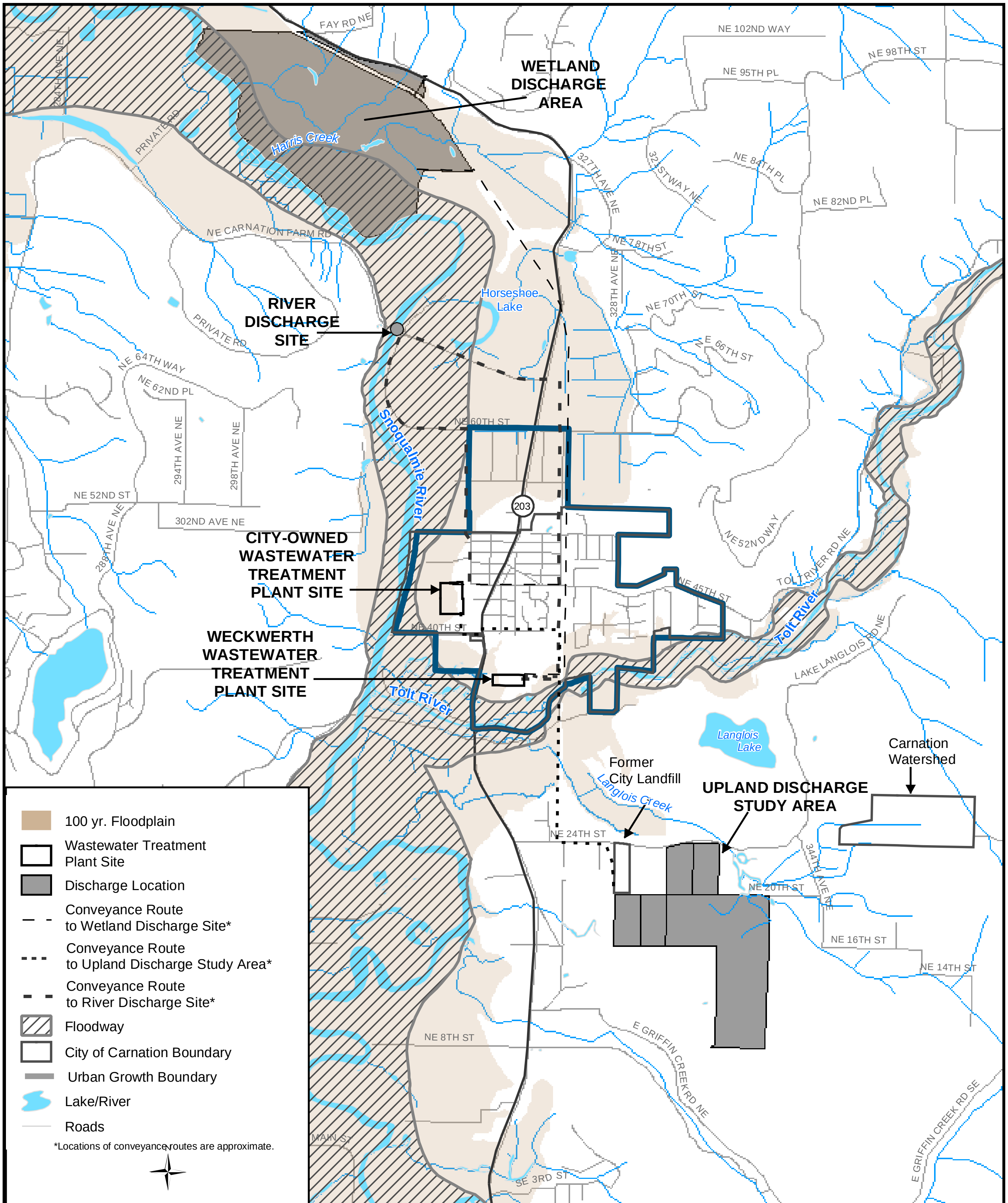

Figure 6-1

Surface Water Bodies and Floodplains

CARNATION WASTEWATER TREATMENT FACILITY FINAL EIS

King County
Department of
Natural Resources and Parks
Wastewater Treatment Division

Data Sources: King County GIS, 2003 **File Name:** L:\ENVIR IMPACTS\2003 Projects\23016 Carnation WWTP\GIS\Surfacewater&Floodplains.mxd 06/01/2004 cm **Prepared by:** King County WLR Visual Communications & Web Unit